

# Health Effect Considerations of HABS

Donna Hill, DVM

Toxicity Assessment Division

National Health and Environmental Effects Research Lab

Office of Research and Development

US EPA

RTP, NC

# Exposure to Cyanobacteria and Cyanotoxins

- Recreational Activities (most common)
- Food
- Drinking water
- Algal dietary supplements
- Medical procedures (dialysis)-rare



# Symptoms of Exposure

Cyanotoxins	Acute Health Effects in Humans	Most common cyanobacteria producing toxin
Microcystin-LR	Abdominal pain, Headache, Sore throat, Vomiting and nausea, Dry cough, Diarrhea, Blistering around the mouth, and Pneumonia, possible cancer promotor	<i>Microcystis, Anabaena, Nodularia, Planktothrix, Fischerella, Nostoc, Oscillatoria, and Gloeotrichia</i>
Cylindrospermopsin	Fever, Headache, Vomiting, Bloody diarrhea	<i>Cylindrospermopsis, Aphanizomenon, Umezakia, Anabaena, Lyngbya, Raphidiopsis</i>
Anatoxin-a group	Tingling, burning, numbness, drowsiness, incoherent speech, salivation, respiratory paralysis leading to death*	<i>Chrysosporum (Aphanizomenon), Cuspidothrix, Cylindrospermopsis, Cylindrospermum, Dolichospermum, Microcystis, Oscillatoria, Planktothrix</i>
Lipopolysaccharides (LPS)	Irritant	All gram (-) bacteria and variable amounts in cyanobacteria

\*death observed in animals

Table adapted from Lesley D'Anglada  
US EPA OW

Routes of Exposure	Recreational	Drinking Water	Food/Dietary Supplement	Occupational	Medical
Ingestion	✓	✓	✓	✓	
Inhalation	✓	✓		✓	
Dermal	✓			✓	
Intravenous					✓

- Severity of health effects depends on toxin(s), dose, route of exposure, and individual's health status.
- Children, elderly, and possibly people with pre-existing health conditions could be at increased risks.

# Exposure Guidelines for Cyanobacteria and Cyanotoxins

EPA Draft Recreational Ambient Water Quality Criteria (AWQC) for Cyanotoxins

Microcystins	Cylindrospermopsin
4 µg/L <sup>a,b</sup>	8 µg/L <sup>a,b</sup>

- a) Swimming Advisory: not to be exceeded on any day
- b) Recreational Criteria for Water Body Impairment: not exceeded more than 10 percent of days per recreational season up to one calendar year.

# EPA Drinking Water Health Advisory (10 Day)

Cyanotoxin	Bottle-fed infants and pre-school children	School-age children and adults
Microcystins	0.3 µg/L	1.6 µg/L
Cylindrospermopsin	0.7 µg/L	3 µg/L

Lower health advisory values for younger children based on higher water intake per body weight for children 5 years old and younger.

# WHO Guidelines for Cyanotoxins

1.0  $\mu\text{g/L}$  MC-LR

- Lifetime exposure
- In water with cyanobacterial cells, this value applies to the total free and cell-bound toxin

# Kansas Health Advisories for Recreational Water

## Public Health Watch—

- A hazardous condition may exist
- Signs posted at public access locations
- Water may be unsafe for humans/animals
  - Discourage water contact
  - 4-20 µg/L toxin
  - or
- Cyanobacteria cell counts 80,000-250,000cells/ml

## Public Health Warning—

- Conditions are unsafe
- Signs posted at all public access locations
  - Water contact should not occur
  - All conditions of Public Health Watch remain in effect
  - Toxin  $\geq 20\mu\text{g/L}$
  - or
- Cyanobacteria cell counts  $\geq 250,000$  cells/ml



## Case Example- Giannuzzi et al 2011, Argentina Lake

- Healthy 19 year old man on jet ski treaded water in an intense Microcystis bloom x 2 hours
- Water conditions 4 hours post-exposure: MC-LR 48.6µg/L and cyanobacteria cell concentration ~34,000 cells/ml
- Man experienced 3 week illness with gastrointestinal stage → pulmonary stage → liver toxicity

# Challenges to Identification of Causative Toxin

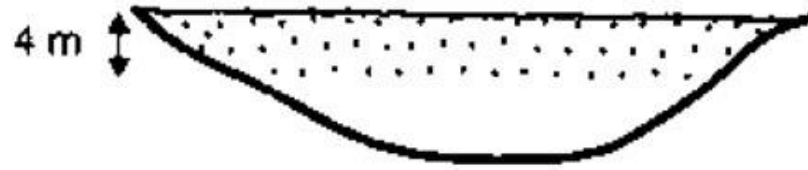
## Patient

- Evidence of cyanobacteria or toxin in bloodstream, stomach contents, or feces could be difficult to detect if medical attention delayed
- Early health effects are often nonspecific and may not be linked to HAB exposure
- Specific toxin identification requires advanced techniques (applies to environmental aspect too)

## Environmental

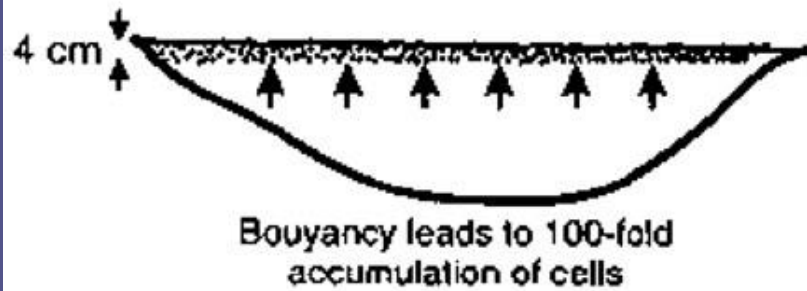
- Cyanobacteria and toxin content are dynamic in respect to time and space in the body of water and within the water column; delayed sampling may represent a different environment

## Lake profile



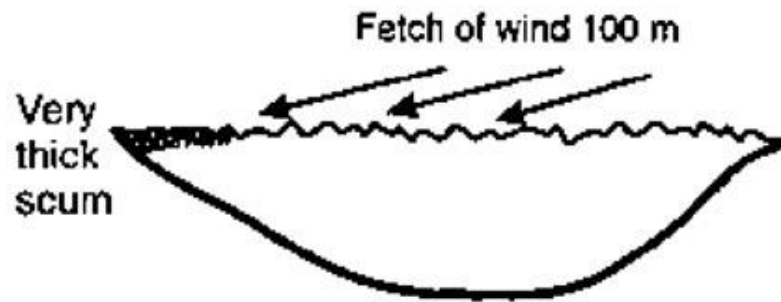
### Moderate risk level:

- $50 \mu\text{g l}^{-1}$  chlorophyll *a*
- or  $100,000 \text{ cells l}^{-1}$
- possibly  $20 \mu\text{g l}^{-1}$  of microcystin in top 4 m of water body



### 100-fold accumulation to high risk level scum:

- $5,000 \mu\text{g l}^{-1}$  chlorophyll *a*
- or  $10,000,000 \text{ cells l}^{-1}$
- possibly  $2,000 \mu\text{g l}^{-1}$  of microcystin in top 4 cm of water body



### 1,000-fold accumulation to very high risk level shore scum if wind sweeps scums from 100 m into 10 m:

- $50,000 \mu\text{g l}^{-1}$  chlorophyll *a*
- or  $100,000,000 \text{ cells l}^{-1}$
- possibly  $20,000 \mu\text{g l}^{-1}$  of microcystin concentrated in one bay of the water body

Schematic illustration of scum-forming potential changing the cyanotoxin risk from moderate to very high (After Falconer et al., 1999)

# If You Are Exposed

- Shower immediately
- Seek medical attention if symptoms develop and let healthcare provider know about HAB exposure
- No “point-of-use” test to confirm exposure
- Supportive care is only treatment- no antidote



# Toxicology Research on Cyanotoxins and Challenge of Health Guidelines and Advisories



- Human data is gold standard, but limited and confounded with other variables
- Mammalian data with appropriate route of exposure
  - Best controlled study type
  - Oral studies limited by cost of toxin

Majority of existing research done using inappropriate route of exposure *in vivo* (intraperitoneal to conserve toxin) or cell culture assays (*in vitro*)- helps elucidate mechanism of toxicity, but interpretation unusable for human exposure



# Chernoff Lab Comparative Toxicity of Eight Microcystin (MC) Congeners

MC-LR	MC-LW
MC-RR	MC-YR
MC-WR	MC-LY
MC-LA	MC-LF

- Given orally by gavage to mice
- Samples taken 24 hours after single dose
- Study repeated with intraperitoneal (i.p.) dose
- To do oral and i.p. studies on two demethylated forms of MC-RR common in Europe

# Chernoff Lab Comparative Toxicity of Eight Microcystin (MC) Congeners

## Relative Toxicity

By oral or injection route:

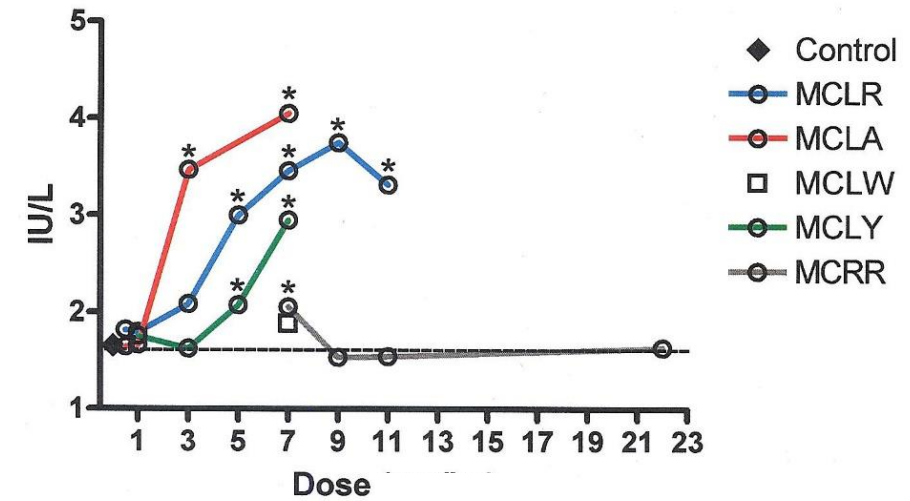
Most toxic:      **MC-LA > MC-LR**

Least toxic:      **MC-RR**

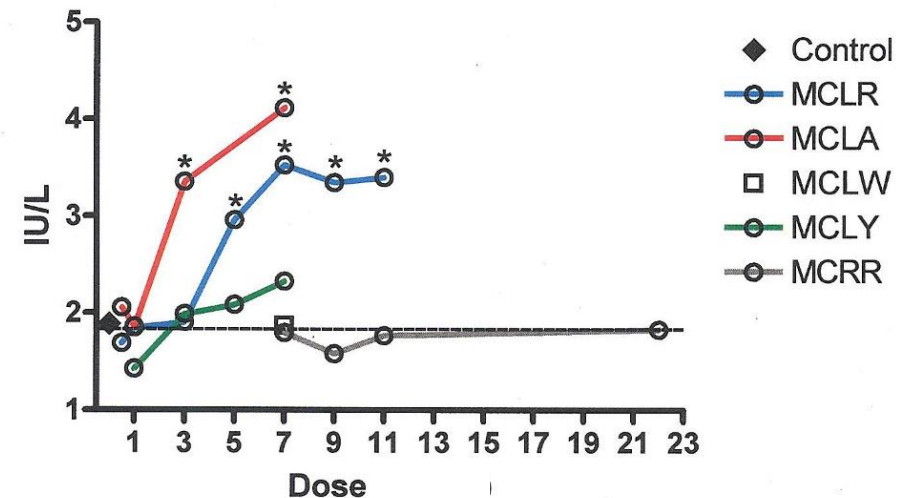
# Study Data

Example of comparison of Microcystin-LR, -LA, -LW, -LY, -RR given orally to mice measured by response of elevated liver enzyme as a marker of liver injury

a. ALT Dose Response - Males



b. ALT Dose Response - Females





# Take Home Points:

- Public Education ✓ (addressed by Kansas HAB program)
- Monitoring, Reporting and Response ✓ (addressed by Kansas HAB program)
- More cyanotoxin animal toxicology data for guidance with human health
- Communication of experiences from Kansas and Region 7 (and beyond) to EPA ORD and our laboratory to help guide research priorities for HABs

## Contacts:

Neil Chernoff, PhD      Lead Toxicologist  
[Chernoff.neil@epa.gov](mailto:Chernoff.neil@epa.gov)

Donna Hill, DVM      Veterinarian  
[Hill.donna@epa.gov](mailto:Hill.donna@epa.gov)

Johnsie Lang, PhD      Environmental Chemist  
[Lang.johnsie@epa.gov](mailto:Lang.johnsie@epa.gov)